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THE FORMATION OF MID-LATITUDE SPORADIC-E LAYERS

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Rosenberg, Edwards and Wright (1963) have reported the simultaneous detection of sporadic-E layers and wind shears at heights of 95-110 km. If a wind system, in which the eastward component of the wind increases with height, is said to have positive west-east shear (+ve W-E shear), then their results include the following items:

(1) One Es layer was observed for a time close to a level of maximum +ve W-E shear, at a height of about 96 km.

(2) A second Es layer was observed close to a level of maximum -ve W-E shear, at a height that gradually decreased from about 109 km to about 100 km.

(3) No Es layer was observed at a second level of maximum +ve W-E shear, which appeared in the later observations at a height of about 110 km, although such a layer might have been present and blanketed by the layer described in (2).

Rosenberg et al note that Whitehead (1961) has concluded that wind shear, in combination with the geomagnetic field, will tend to produce an Es layer near a level of maximum +ve W-E shear (in present nomenclature), and they correctly infer that the same analysis would yield a reduction of ionization at a level of maximum -ve W-E shear. The implication is, then, that observation (1) can be explained by this 'magnetoshear' mechanism, while (2) is anomalous and (3) may be. It is the purpose of this note to point out that a reinterpretation of the data is required, as a consequence of a correction to Whitehead's analysis.

The requisite correction is a deletion of the minus sign in Equation (2) of Whitehead (1961). (A corresponding change of sign is required in Equation (1), although not in the appendix, of that paper; the error recurs in Whitehead (1963), but there plus signs must be changed to minus signs because the coordinate axis is reversed. That a conflict occurred on the sense of shear required for Es production, as between the analysis of Whitehead and that of Axford (1963), was pointed out to me by J. W. Wright and confirmed by M. A. MacLeod; that the necessary correction is as stated above has been confirmed by K. D. Kleis and by J. D. Whitehead in the course of private communications.) It then follows that the magnetoshear mechanism tends to produce an Es layer near a level of maximum -ve W-E shear, and this conclusion can be confirmed by a simple physical picture (see Figure 1).

Clearly it is now observation (2) of Rosenberg et al that should be associated with the magnetoshear mechanism, while (3) poses no problem whatever on this count; (1) must be subjected to a new interpretation.

It seems relevant to note that, as reported by Rosenberg et al, the atmosphere near 96 km was turbulent. The strength of the turbulence might well be expected to increase with the shear of the larger-scale winds -- and for this, the north-south components would be equally relevant, but the total shear was indeed a maximum near the 96 km level -- and increased scattering of radio waves might well result. Theories of Es layers based on turbulence have not achieved marked success quantitatively in the past, but seem now to merit further exploration.

If turbulence is important for (1), its possible role in (2) and (3) may also be queried. The height at which the ambient turbulence ceased was not reported by Rosenberg et al, but heights near 100 km are quite typical. According

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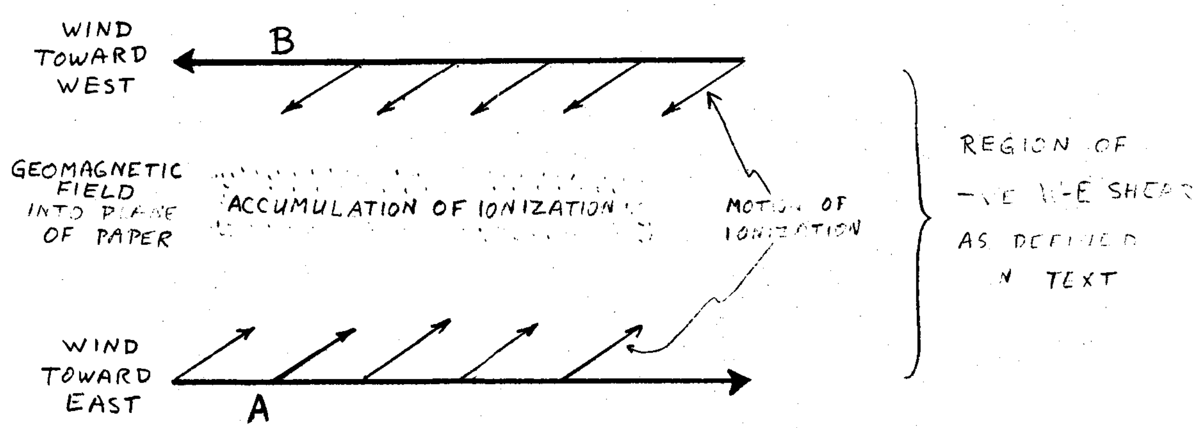
Caption: Figure 1: Elementary construction indicating the sense of the magnetoshear mechanism in the E region. The plane of the paper is to be taken as an east-west vertical plane at the magnetic equator, viewed from the south. A wind motion A directed toward the east sets the positive ions into motion toward the east, through collisional interaction, but the Lorentz force tends to deflect them upward. The oppositely-directed wind B results in an opposite motion of the positive ions, and so to an accumulation of ionization between. The electrons tend to follow, being influenced more by the resulting electric field than by collisional interaction. The steady-state distribution is influenced by a variety of factors, and varies with latitude, as discussed by Whitehead (1961, 1962) and Axford (1963); but the tendency for ionization to accumulate at a level of -ve W-E shear, as illustrated here, persists.



to one interpretation (Hines, 1963, p. 27), this termination of turbulence results from a removal of small-scale internal gravity waves and of their destabilizing influence; the upper levels are then too stable to permit any shears, however great, to produce turbulence. Whether this interpretation is valid in its extreme form or not, it does seem that a given shear is more capable of producing turbulence at 96 km than at 110 km (for example), and there is no reason to expect in advance that the observed shears at the higher levels should be accompanied by turbulence. Observation (2) may then relate only to the magnetoshear mechanism, and observation (3) comes as no surprise.

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